

VENUS AND BEYOND USING THE ARIANE ASAP LAUNCH CAPABILITY*

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ABSTRACT

The cost of executing planetary missions in the next ten years is expected to decrease significantly. The principle reason is that new technology is reducing spacecraft mass while increasing capability. Another reason is that launch costs are expected to decrease. A move in this direction is to permit important planetary missions to fly as secondary payloads, and this opportunity is now provided by the French on the Ariane 5 using the Ariane Structure for Auxiliary Payloads (ASAP).

The ASAP will fly on GEO missions, and can boost up to eight 100 kg (or 200 kg, if paired) payloads into the elliptical geosynchronous transfer orbit (GTO), which delivers large communication satellites to GEO. An efficient multi-burn method has been developed by this author to deliver these small spacecraft from GTO to Mars and other destinations.

This method, referred to here as Moon-Earth Gravity Assist (MEGA), requires 3 or more major maneuvers together with close flybys of the earth and moon. An example for a Mars 2003 mission (not to scale) is shown in Figure 1, where, once in GTO, the first burn sends the spacecraft beyond the Moon to a distance of 1.2 million kilometers. At apogee, the second burn targets to an encounter with the Moon such that a swingby returns the spacecraft to the Earth with a 300 km perigee, and with an inclination such that a perigee burn will send the spacecraft off to Mars with the required escape velocity vector. Details of this method, specifically for Mars missions, can be found in Reference 3. A similar strategy works for Venus, with some caveats.

This method is required to work for any Ariane 5 launch date over a three-month period, to ensure a high probability of getting off the ground. The launch period is provided by fixing the Earth escape date (3rd burn), but allowing the high ellipse (beyond the Moon) period to vary by one or two months, and also allowing a one to two month wait time in GTO (or other orbit) before the first burn is performed. Figure 2 shows the trajectory profiles for the early and late GTO launch dates for a Mars 2003 mission.

Venus, which is an inner planet, poses special problems for the MEGA process. The escape direction is reverse that of Earth's motion, and the GTO apogee arrival

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hour (noon local time, usually) is not well placed for the MEGA process to work. In fact, for the proper GTO orientation, the secondary payload needs to be launched 6 to 9 months before the required Earth escape date, as shown in Figure 3 for a Venus 2004 launch. A later launch date is possible if the lunar flip option is used. Here, two lunar encounters are required to flip the GTO major axis 180 deg (see Figure 4). This process will be explained further in the paper.

Also, Venus, because of its high velocity about the sun, and its significant mass, is an excellent gravity assist body in the solar system. Past examples are the Mariner Venus-Mercury mission (MVM) in 1974, the Galileo mission in 1989, and the Cassini mission in 1997. "Beyond" in the title of this paper refers to other bodies that may be reached using a Venus gravity assist (VGA). The paper will present and discuss a list of possible missions which are enabled by VGA's, including those to comets and asteroids, as well as to the inner and outer planets. The MEGA process is then analyzed for each to determine the feasibility of using the ASAP launch opportunity to perform the mission.

REFERENCES

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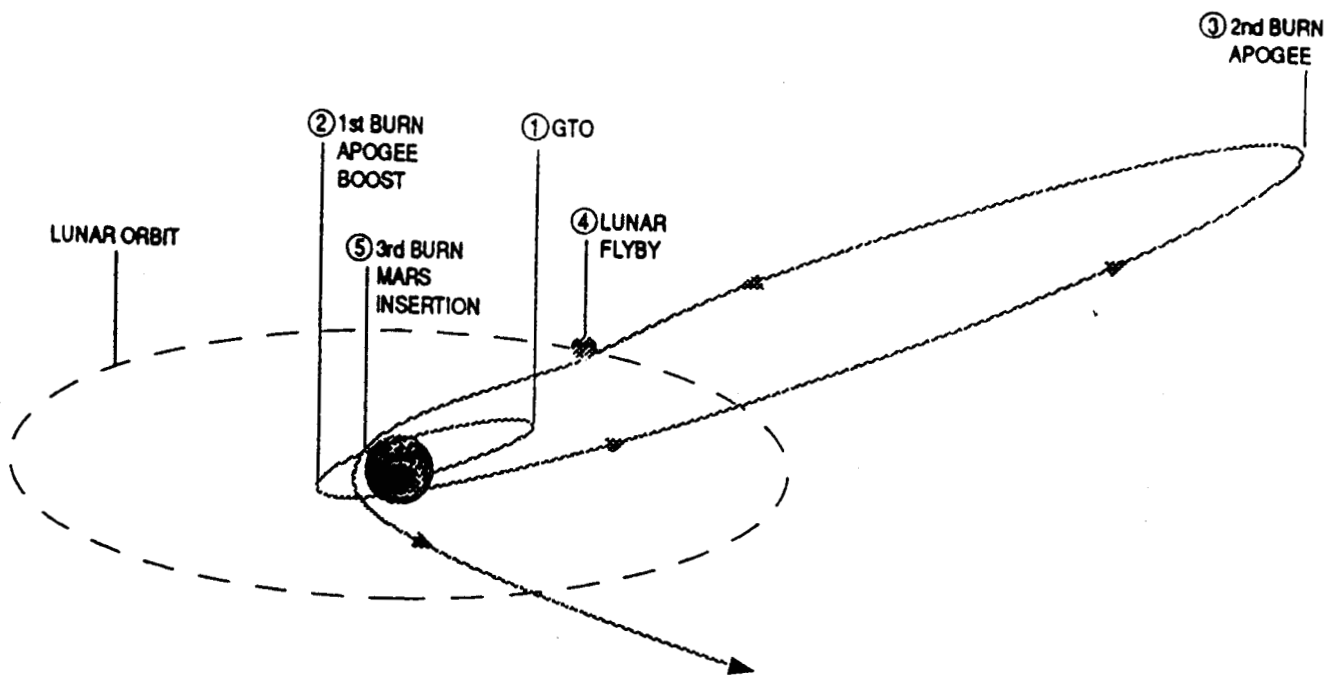


Fig. 1 GTO to Mars Using the 3-Burn Moon-Earth Gravity Assist

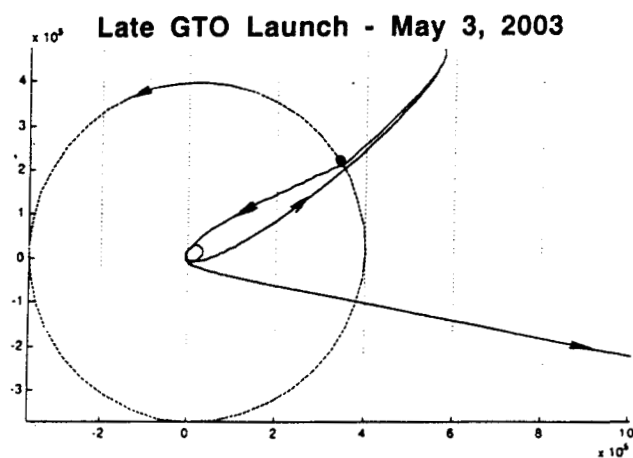
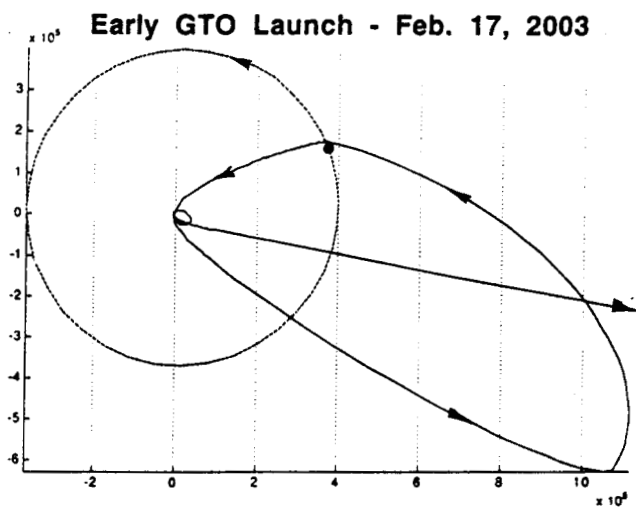


Fig. 2 Three-Burn Trajectory Plots for Mars 2003 Type 1

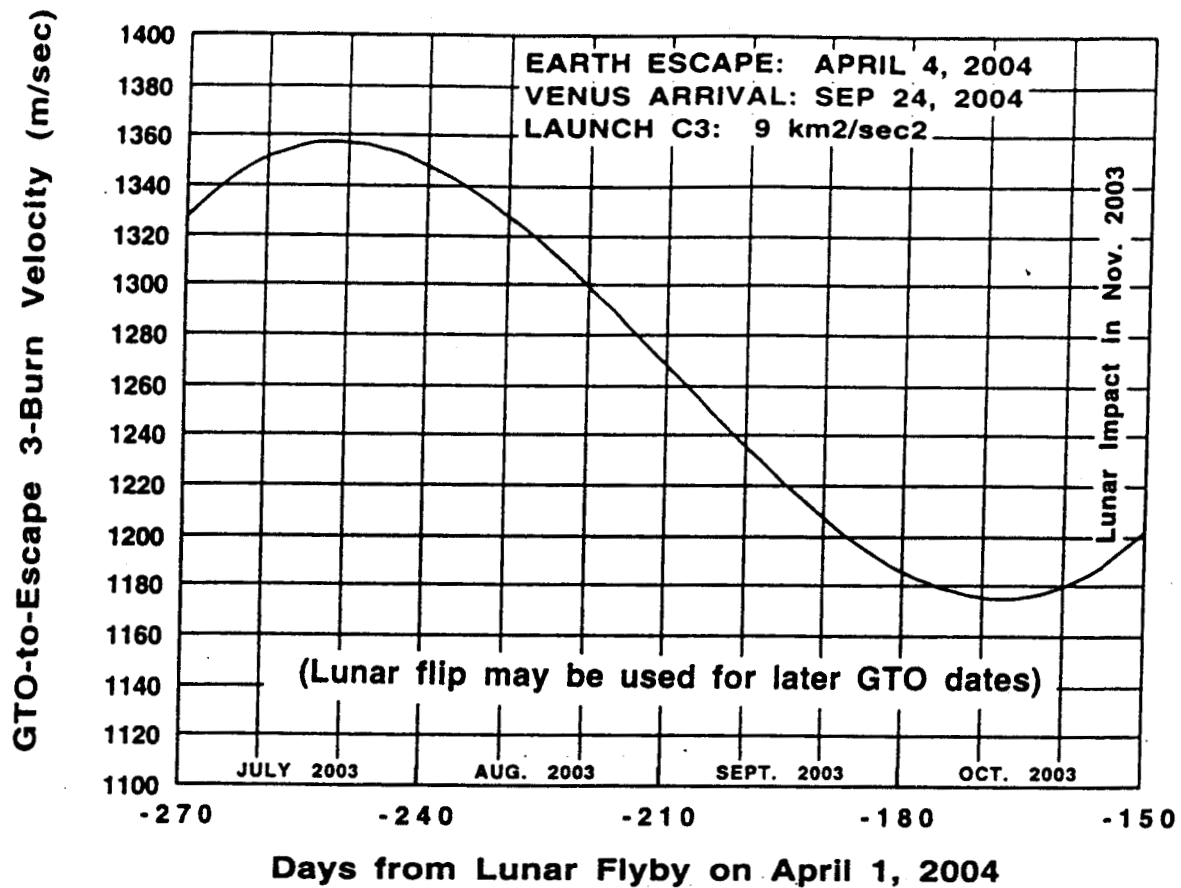


Figure 3. The GTO MEGA Delta-V Requirements for the Venus 2004 Opportunity

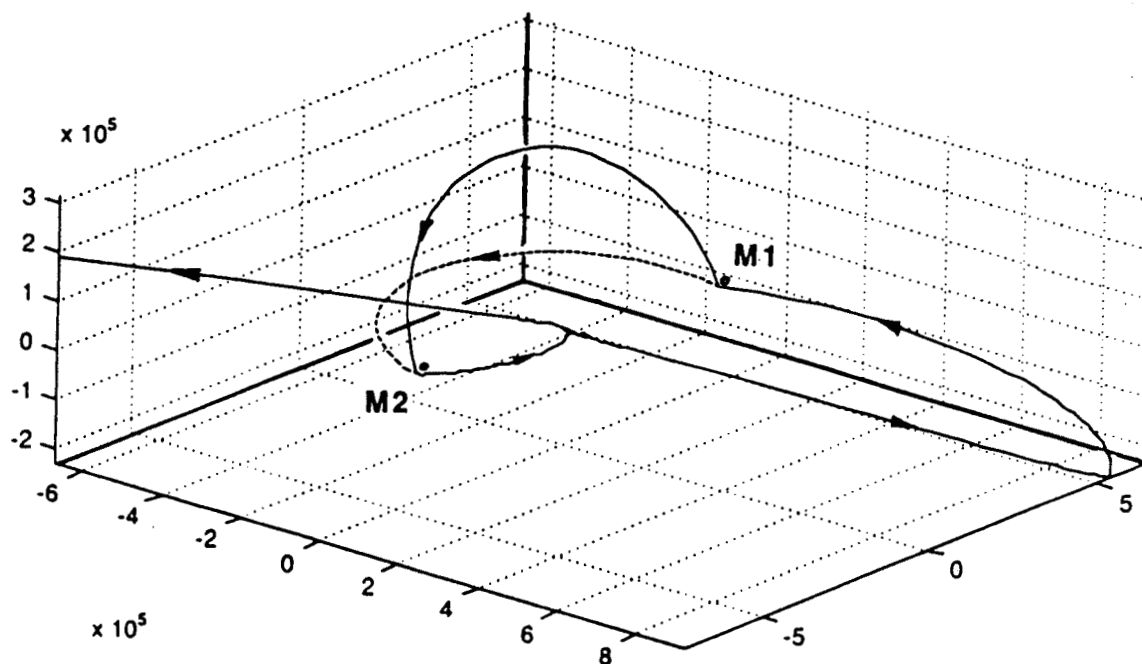


Figure 4. Example of the MEGA Lunar Flip Profile for the Venus 2004 Opportunity